**Section 2: Properties of Waves**

(**READ ONLY:** Properties of waves, such as the height of the waves and the distance between crests, are useful for comparing and describing waves.)

***Amplitude***

(**READ ONLY:** If you tie one end of a rope to the back of a chair, you can create waves by moving the free end up and down. If you shake the rope a little, you will make a shallow wave. If you shake the rope hard, you will make a tall wave.)

* The **amplitude** of a wave is related to its height.
* A wave’s amplitude is the maximum distance that the particles of a medium vibrate from their rest position.
* The rest position is the point where the particles of a medium stay when there are no disturbances.
* The larger the amplitude is, the taller the wave is.

(**READ ONLY:** Figure 1 shows how the amplitude of a transverse wave may be measured.)

* The amplitude of a transverse wave is measured from the rest position to the crest or to the trough of the wave.

***Larger Amplitude–More Energy***

(**READ ONLY:** When using a rope to make waves, you have to work harder to create a wave with a large amplitude than to create one with a small amplitude. The reason is that it takes more energy to move the rope farther from its rest position.)

* A wave with a large amplitude carries more energy than a wave with a small amplitude does.

***Wavelength***

* Another property of waves is wavelength.
* A **wavelength** is the distance between any two crests or compressions next to each other in a wave.
* The distance between two troughs or rarefactions next to each other is also a wavelength.
* The wavelength can be measured from any point on a wave to the next corresponding point on the wave.
* Wavelength is measured the same way in both a longitudinal wave and a transverse wave (as shown in **Figure 2.****)**

**(Figure 2** Measuring Wavelengths)

* Wavelength can be measured from any two corresponding points that are adjacent on a wave.

***Shorter Wavelength–More Energy***

(**READ ONLY:** If you are making waves on either a spring or a rope, the rate at which you shake it will determine whether the wavelength is short or long. If you shake it rapidly back and forth, the wavelength will be shorter. If you are shaking it rapidly, you are putting more energy into it than if you were shaking it more slowly.

* A wave with a shorter wavelength carries more energy than a wave with a longer wavelength does.

***Frequency***

(**READ ONLY:** Think about making rope waves again. The number of waves that you can make in 1 s depends on how quickly you move the rope. If you move the rope slowly, you make only a small number of waves each second. If you move it quickly, you make a large number of waves).

* The number of waves produced in a given amount of time is the **frequency** of the wave.
* Frequency is usually expressed in *hertz* (Hz). For waves, one hertz equals one wave per second (1 Hz = 1/s).

(**READ ONLY:** Figure 3 shows a wave with a frequency of 0.2 Hz.

* Frequency can be measured by counting how many waves pass by in a certain amount of time.

(**READ ONLY:** Here, two waves went by in 10 s, so the frequency is 2 /10 s = 0.2 Hz.

***Higher Frequency–More Energy***

(**READ ONLY:** To make high-frequency waves in a rope, you must shake the rope quickly back and forth. To shake a rope quickly takes more energy than to shake it slowly.

* If the amplitudes are equal, high-frequency waves carry more energy than low-frequency waves.

***Wave Speed***

* **Wave speed** is the speed at which a wave travels.
* Wave speed (*ν*) can be calculated using wavelength (λ, the Greek letter *lambda*) and frequency (ƒ), by using the *wave equation*, which is shown below:

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***Frequency and Wavelength Relationship***

* Three of the basic properties of a wave are related to one another in the wave equation–wave speed, frequency, and wavelength.

(**READ ONLY:** If you know any two of these properties of a wave, you can use the wave equation to find the third.)

(**READ ONLY:** One of the things the wave equation tells you is the relationship between frequency and wavelength. If a wave is traveling a certain speed and you double its frequency, its wavelength will be cut in half. Or if you were to cut its frequency in half, the wavelength would be double what it was before.)

* frequency and wavelength are *inversely* related.

(**READ ONLY:** Think of a sound wave, traveling underwater at 1,440 m/s, given off by the sonar of a submarine like the one shown in **Figure 4.**If the sound wave has a frequency of 360 Hz, it will have a wavelength of 4.0 m. If the sound wave has twice that frequency, the wavelength will be 2.0 m, half as big.)

* Submarines use sonar, sound waves in water, to locate underwater objects.
* The wave speed of a wave in a certain medium is the same no matter what the wavelength is.
* The wavelength and frequency of a wave depend on the wave speed, not the other way around.